Research History : P.R. Page

INVERSION AND PREDICTION IN THEORETICAL NUCLEAR PHYSICS

The problem:

- Fitted large experimental data sets (up to 4000 data points) with a partial wave analysis model to obtain the lowest χ^2 per degree of freedom.
- Obtained with a modified "variable metric" local minimization method the fitted adjustable model parameters, which are the elements of the R-matrix. They indicate the connections between various nodes in a network, where the nodes are pairs of nuclei.
- Studied how the R-matrix is related in a complicated way to the potential between nucleons (which are the constituents of nuclei). The "**inversion**" of the R-matrix gives the potential, which gives information about the way how the system (the set of nucleons) interacts.
- Used the fitted R-matrix to **predict** nuclear information not measured experimentally.

Experience obtained:

- Calculated the **poles** and **residues** of the elements of a complex matrix related to the R-matrix, yielding important nuclear information.
- Developed the 20000 line R-matrix code to incorporate nodes containing three nuclei instead of just allowing pairs, as before. Coded function evaluations involving complex number arguments coming from contour integration. Numerical Gauss-Legendre integration.
- Built a **database** of experimental data.
- Learned about vulnerabilities due to homeland security: Performed a nuclear data evaluation of nitrogen, which is relevant to the interrogation of containers at ports.

THEORETICAL ELEMENTARY PARTICLE PHYSICS

Research for postdoctoral positions:

- Studied **path integration** in quantum field theory, which is a way to statistically average over a large number of paths to go from A to B with some weight (stochastic process): Proved a theorem involving **correlation functions** of the path integral.
- Proved a theorem relating the undiagonalized and diagonalized elements of a hermitean matrix with application to elementary particle physics.
- Extended my Ph.D. string model (below) to three strings connected at a common junction. Fixed the endpoint of each string and calculate the energy of the system with a numerical **minimization** method. Allowed the endpoints to move freely and evaluate the energy numerically by finding the **eigenvalues** of the Hamiltonian.

Research for academic degrees:

- **M.Sc.** : Calculated loop diagrams using special mathematical functions.

- **Ph.D.** : Constructed a string model where the beads connected via a string were allowed to oscillate with **Gaussian distributions**. The string broke into two other strings.
  - Calculated analytically the overlap integral of the three Gaussian distributions as a function of the break point in terms of rotation functions.
  - Specialized to the first two **Fourier modes** "breaking" to the two lowest modes. Coded results. Applied to elementary particle physics.

Equations solved:

- Two-, three- and multi-body Schrödinger equation (a **diffusion**-type equation); as well as the more complicated Dirac and Bethe-Salpeter equations.

OTHER

- **Bioinformatics:** Analysed gene expression data in bioinformatics in 2000. Studied gene expression patterns, and the way each gene is connected to other genes in a **network**.
  - Invert the gene expression patterns to obtain information about how each gene in the network interacted with other genes.
  - Used a linear matrix model (**Markov chain**) and obtained the matrix computationally by principal component regression.

- Vacation work involving computational **numerical methods** applied to nuclear fusion and fission during 1988-89.
- Lectured course "**Random Processes** in Physics" in 1996, where, amongst other subjects, Brownian motion and diffusion were studied.